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METHOD OF DIAGNOSING A GOLF SWING

BACKGROUND OF THE INVENTION

Field of the Invention

The invention concerns a method and an apparatus for analysing the pattern of movements of the thoracolumbar part of the spinal column of a human being in a golf swing.

Analysis of the movements involved in a golf swing indicates that the main load and stressing is to be found in the lower third of the axial skeleton. Video recordings of that anatomical region also clearly show possible errors in the position of address and at any moment in time of the golf swing. Nonetheless a video action, however perfect it may be, of a golfing instructor on the range is not adequately suitable for explaining reasons for a defective striking technique or the causal relationships between a defective striking technique and back complaints.

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SUMMARY OF THE INVENTION

Therefore the object of the present invention is to provide a suitable analysis method and an apparatus for carrying it out, by means of which golf swing analysis can be implemented in a very precise, rapid and inexpensive manner.

In accordance with the invention, that object is attained by a method and an apparatus for analysing the pattern of movements of the thoracolumbar part of the spinal column in a golf swing.

In the method and apparatus according to the invention for example three ultrasonic measurement value pick-ups are so applied to the back of a guinea-pig or experimentee that the movements of the upper region of the spinal column can be recorded by means of two of the measurement value pick-ups and the movement in the lower region of the spinal column can be recorded by the third measurement value pick-up. By means of the measurement value pick-ups it is possible to define three-dimensional movement cursions and amplitudes (in degrees of angle). Such measurement value pick-ups - also referred to as triple markers - are located cranially at the height of the upper spinal column and the

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lower spinal column on the connecting line of the two upper rear intestine leg extensions in caudal relationship. In this case the degrees of angle in the sagittal plane (anteflexion), horizontal plane (rotation) and frontal plane (lateral flexion) are given by a reference marker at all times. Included in that respect are moments (various stages) in a golf swing, such as for example the address position, the upper reversal point, the striking point and the final position of the golf club in the golf swing.

The data ascertained with the measurement value pick-ups are passed to a data processing apparatus, for example a personal computer (PC), which processes the recorded measurement value data. In addition, measurement value comparative data are also stored in that data processing apparatus and, from the comparison of the recorded measurement value data with the measurement value comparative data, it is possible to derive reliable information about the quality of the golf swing posture or the pattern of movements of the thoracolumbar part of the spinal column in the golf swing. The result of the pattern of movements of an experimentee are so represented on the display device which is coupled to the data processing apparatus, that the viewer can see the quality of the measured golf swing of the experimentee, in relation to other experimentees.

The data material of the measurement value comparative data is ascertained from the investigation of a plurality of experimentees. In that situation, the experimentees perform a plurality of hits using different clubs (for example a 5 wood, a 6 iron, a wedge, and a putter). For evaluation purposes, it has been found that the most appropriate course of action is to analyse for each experimentee only one hit, namely the fifth hit (second hit with a 6 iron) as the movement of the spinal column is almost identical in all hits, except with the putter. As the movement of the spinal column is extremely slight when putting, it is desirable only to take account of the starting position when putting.

With the measurement value pick-ups, it is possible to record the various movements and directions of movement of the spinal column measurement points and represent them in various curves. In that respect, in the representation thereof, the alpha1 curve detects the rotation of the LSC (lower spinal column

region), the alpha2 curve detects the rotation of the TSC (thoracic spinal column region), the beta1 curve detects the sagittal flexion of the LSC, the beta2 curve the sagittal flexion of the TSC, the gamma1 curve the lateral flexion of the LSC and the gamma2 curve the lateral flexion of the TSC.

For the purposes of analysing the measured data sets it is possible to use a statistical classification method and self-organised cards which permit direct quality assessment of an experimentee in comparison with the measurement value comparative data.

The invention is based on the realisation that characteristic differences between the swing curves of players of different classes of performance can be represented and that also the properties of the curves are important in order to ascertain the distinction between the classes of performance. It is also possible with the ascertained data to determine the optimum swing and also to ascertain from the ascertained data the relationship between given properties of the swing curves and back complaints on the part of the experimentee.

In a specific test procedure a total of 88 male experimentees in each class of player were investigated three-dimensionally by means of an ultrasound-supported test method at all moments in time in a golf swing (inter alia also the address position, the backswing, the downward swing and followthrough and the final position). By interpreting the measurement value curves of the individual experimentees it was possible to find out characteristic features of an optimum golf swing, and overall it was possible to define 124 criteria which make it possible to define professionals, handicap players and beginners. By illustration and definition of those features it is possible to recognise an optimum pattern of movements of the thoracolumbar parts of the axial skeleton. Accordingly the analysis method according to the invention can be deemed to be suitable for illustrating and analysing an optimum swing performance. To the same extent this method can be helpful in avoiding golf-specific injury patterns and proposing specific targeted therapeutic movement programs.

The information content of the measurement value data obtained was investigated with statistical and neuronal classification methods. The part played by

the properties which were found to be important for distinguishing the classes involved was visually displayed with self-organised cards.

The data obtained were standardised to the beginning of the hit (from the maximum point of rotation of the TSC back 50 steps in time to the right) so that it was possible to apply automatic processing of classification features. In order to be able to obtain comprehensible results it is important in this respect to supply to the automatic analysis method data which are composed of individual properties of the curves which can also be interpreted for a human being, such as for example swing duration, speed of rotation and acceleration.

For each curve (rotation, sagittal flexion, lateral flexion for TSC and LSC (six curves per hit)), eleven to twenty four properties are extracted, depending on the respective type of curve involved. In total therefore 124 properties (P01-5-P ... P30-5-A ... P88-5-B) are only named for the curves.

The data from questionnaires (age, height, handicap and so forth) as well as measured values from medical examination are treated separately.

A series of the properties which optimise recognition of the playing strength of the experimentee was then sought. It is only with difficulty that the playing strength of a golfer can be subdivided into a plurality of classes, as the transitions are fluid. It is preferable to divide the playing strengths into three classes, namely professionals, amateurs and beginners.

In order to be able to define an optimum swing the properties which most clearly distinguish the professionals from the others were selected. Here the recognition value is very much higher (up to 66%). That value is increased to 72% by combining given properties.

In the method according to the invention a (self-organised) card is trained for the properties of a swing of each experimentee in order to show the most important items of information contained in those data, for the purposes of distinguishing the classes. After the training operation the card includes a two-dimensional representation of the three-dimensional data set. Adjacent fields on the card in that respect represent similar patterns from the data set.

The arrangement of the fields on the cards is retained while properties such as handicap, height, age and so forth can be represented by properties of the swing in gray values on the card. The gray values indicate high (dark) or low (light) values for the respective parameter being considered.

With the method and apparatus according to the invention, it was possible in as many phases as possible and preferably in each phase of the golf swing for same to be sufficiently accurately recognised, which is made possible by the sequence in respect of time of the measured data.

In this respect, there are in particular clear features which distinguish a good golf swing.

In general terms, in regard to a good golf swing, it can be said that the movements in the TSC are markedly greater than in the LSC, but they are similar from the point of view of structure in the respective direction of movement. The alpha curve (rotation), with the back swing movement, firstly goes into the negative region, to a maximum, the end of the back swing. With the followthrough the curve goes from the negative into the positive region, until it reaches a maximum, the end of the swing. The beta curve (sagittal flexion) is determined by a maximum (maximum sagittal flexion at the end of the back swing) before there is a minimum which describes the slight sagittal extension in the back swing movement. After the minimum the curve goes more strongly into the negative region to a minimum which is the maximum sagittal extension at the end of the swing. The second minimum is markedly greater than the first minimum. The gamma curve (lateral flexion) is characterised by a maximum (maximum lateral flexion towards the right at the end of the back swing) and by a minimum (maximum lateral flexion towards the left at the end of the swing). After the minimum, there is again a maximum which indicates the magnitude of the lateral flexion towards the right at the end of the swing, the weight adjustment at the end of the swing.

Experimentees who did not satisfy the above-indicated criteria in their swing curves were excluded from the analysis method when determining the comparative data.

The (self-organised) card material which results from 124 parameters shows marked delimitations of professionals in relation to other players and represents a marked delimitation in respect of the beginners (gray values represent handicap; in this respect light denotes a low handicap (that is to say the professional area)). In the cards each individual field denotes a given swing pattern. It was found that the swing patterns of professional players are only limited to a given range. Those swing pattern card fields are in mutually adjacent relationship and are emphasised by the delimitation line in the cards.

A good curve swing is firstly to be seen on the basis of the typical curve configuration. In order to be able to better define the swing performance for professionals, the best parameters which are suitable for distinguishing the professional from others are additionally necessary. The best individual parameters for recognising the professionals and thus also for determining the optimum swing are as follows:

Parameters for the rotational movement (sorted in accordance with the time sequence of the swing):

In the case of a good swing the moment in time of the maximum rotational acceleration of the LSC occurs at the same time as the reversal point between the end of the back swing and the beginning of the forward swing, at TU 70 (grid 9).

The moment in time of the maximum negative acceleration of the rotation of the LSC in the forward swing and followthrough is in all precisely 17 TU after the moment in time of the maximum rotational acceleration of the LSC. There is therefore a direct relationship between those two features. In the case of a good swing the moment in time of the maximum negative rotational acceleration of the LSC is at TU 87 (grid 11).

The rotational movement of the LSC lasts in the case of a good swing for 0.51 seconds which corresponds to 17 TU (grids 9 and 11).

Parameters for the sagittal movement (sorted in accordance with the time sequence of the swing):

Back swing:

The maximum flexion acceleration of the TSC in the back swing is lower in the case of the beginners than in the case of the professionals and amateurs. A maximum acceleration through 0.3° in 0.03 seconds in the back swing is an optimum for a good swing (grid 66).

The speed through 1° in 0.03 seconds is to be specified as the optimum flexion speed of the TSC in the back swing. In particular beginners reach lower flexion speeds (grid 62).

The moment in time of the maximum sagittal flexion of the LSC is around TU 70 (grid 26) in the case of a good swing.

Forward swing and followthrough:

The moment in time of the maximum acceleration of sagittal extension of the LSC, in the case of a good swing, is between TU 70 and TU 75 (grid 46).

The moment in time of the maximum extension speed of the LSC in the case of a good swing is around TU 84. It is only in the case of some beginners that that moment in time is between 4 and 6 TU later (grid 40).

The maximum extension speed of the LSC in the forward swing and followthrough, for a good swing, should be no slower than 1.2 (grid 39).

The maximum negative extension acceleration should be no less than 0.2° in 0.03 seconds (grid 47).

The average extension speed of the TSC should be no slower than 0.4° in 0.03 seconds (grid 61).

The maximum extension speed of the TSC should be no less than 1° in 0.03 seconds (grid 64).

End of the swing:

The LSC at the end of the swing should exhibit an extension of at least 1° (grid 29).

The TSC at the end of the swing should exhibit an extension of at least 5° (grid 54).

The moment in time of the maximum extension of the LSC should take place before TU 110 (grid 30).

The moment in time of the maximum extension of the TSC should take place before TU 104 (grid 55).

Parameters for the lateral movement (sorted in accordance with the time sequence of the swing):

Forward swing and followthrough:

The moment in time of the maximum flexion speed of the LSC should be no later than TU 83 (grid 88).

The moment in time of the maximum lateral flexion of the LSC towards the left should be no later than TU 90 (grid 76).

End of the swing:

For a good swing the moment in time of the maximum acceleration of the LSC towards the right should be prior to TU 92 (grid 96).

The maximum acceleration of the TSC towards the right should be no less than 1° in 0.03 seconds (grid 120).

The moment in time of the maximum flexion speed of the LSC towards the right should be around TU 90 and should occur no later than TU 95 (grid 90).

The maximum negative acceleration of the TSC towards the right should be no less than 0.15° in 0.03 seconds (grid 122).

The moment in time of the maximum negative acceleration of the LSC towards the right should not occur after TU 105 (grid 98).

The crucial aspect in regard to recognising professionals is the movements in the frontal and sagittal planes. A value for determining the rotation occurs at the seventh place. Further clear features which are typical of professionals are as follows:

1. Rotation

- Address position in the LSC is different, rather towards the left than towards the right. No. 0. In regard to the TSC here the professionals rotate furthest towards the right. No. 12.

- The magnitude of the maximum rotational angle of the LSC towards the right at the end of the back swing is medium in the case of the professionals, while

a small angle is typical of beginners. No. 1. In the case of the TSC the rotational angle towards the right is greater, in the case of all experimentees of approximately equal size. No. 13.

- The magnitude of the maximum rotational angle of the LSC towards the left at the end of the swing is medium in the case of the professionals, the angle is small in the case of the beginners. No. 2. In regard to the TSC here a medium value is typical of the professionals and also of most of the other experimentees. No. 14.

- The total angle of rotation of the LSC in the forward swing and followthrough is small or large in the case of the beginners, large in the case of some amateurs, and medium in the case of the professionals. No. 3. In regard to the TSC, a medium to somewhat higher value is typical of the professionals. It seems to be similar in regard to all others, in which respect in regard to some beginners in relation to whom extremely large or extremely small values in respect of the LSC are typical, those values for the TSC are precisely at the other extreme. No. 15.

- The duration of the forward swing and followthrough in the case of the professionals is short in the LSC. No. 4. In the TSC it is also short or somewhat longer, while the rotation of the TSC in the case of all experimentees lasts somewhat longer than that of the LSC. No. 16.

- The moment in time of the maximum speed of rotation in the forward swing and followthrough is only early in the case of the professionals, otherwise it is medium. No. 7.

- The average speed of rotation of the LSC in the case of the professionals is not as high as in the case of some amateurs. Beginners rotate more slowly. Nos. 5, 6, 8 and 10. The amateurs and professionals whose speed of rotation in the LSC is very high have a low average speed of rotation in the TSC. The experimentees who rotate rather slowly in the LSC rotate faster in the TSC. Nos. 17, 18, 20 and 22.

2. Sagittal flexion

- In the address position the magnitude of the sagittal flexion in the TSC is almost always equal and opposite to the sagittal flexion in the LSC. The

professionals involve a greater degree of flexion in the LSC than in the TSC, where only slight angles of inclination are to be found. For some beginners severe sagittal flexion in the TSC is typical. In the case of those experimentees only a slight degree of flexion of the LSC is to be found. Nos. 49, 24.

- In the case of the professionals the moment in time of the maximum sagittal flexion of the LSC at the end of the back swing is very early in comparison with the other experimentees, the TSC reaches that maximum mediumly fast. Nos. 26, 51.

- The extension angle of the LSC in the case of the professionals is great in the back swing in comparison with the others, while in regard to the TSC it is rather small in the case of the professionals. Nos. 27 and 52.

- The sagittal extension angle at the end of the swing is at the greatest in the case of the professionals in the TSC and the LSC. Nos. 29 and 54. The moment in time of that maximum extension angle is at the earliest in the case of the professionals. Nos. 30 and 55.

- The extension movement in the forward swing and followthrough occurs in the case of the professionals in the TSC and the LSC very quickly and very early in comparison with the others. Nos. 36, 39, 40, 44, 45, 46, 47, 48, 60, 61, 62, 64, 65, 66, 67, 68 and 70.

3. Lateral flexion

- Lateral flexion in the address position of the TSC is in the medium region in the case of all experimentees. No. 99, while in most thereof it is further towards the right for the LSC. A medium value is respectively indicated for the professionals, the LSC somewhat more towards the right. No. 74.

- The magnitude of the lateral flexion angle towards the left at the end of the swing is medium in the case of the professionals in comparison with the others. Nos. 75 and 100.

- The moment in time of the maximum lateral flexion towards the left at the end of the swing is at the earliest in the case of the professionals in the LSC, while for the TSC the moment in time is rather medium-fast. Nos. 76 and 101.

- The maximum lateral flexion towards the right in the back swing is greater in the LSC in the case of the professionals than in the case of most of the others. No. 77. For the TSC it is rather on average of medium magnitude. No. 102.

- The lateral displacement towards the right at the end of the swing is of medium magnitude in the case of the professionals. Nos. 79 and 104. For beginners, that is a good recognition feature as they bend severely towards the right with the LSC. No. 82.

- Professionals move their weight fastest from right to left in the TSC in the forward swing and followthrough. Nos. 88, 90, 92 and 96.

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BRIEF DESCRIPTION OF THE DRAWINGS

The following figures illustrate a case example of the inventive method. The figures show:

Figure 1 shows a card illustration of different swing patterns. In this respect adjacent fields in a card denote similar swing patterns. Entered in each card field are three bars of which the left shows the number of professionals, the middle shows the number of amateurs and the right one shows the number of beginners.

Figures 2a, 2b and 3 show surface card representations in respect of the alpha1, beta1 and gamma1 curves (Figure 2) and alpha2, beta2 and gamma2 curves (Figure 3).

In this respect also a light card area denotes a low handicap and a dark area a high handicap.

The illustrations in Figures 4a-e show the various curves alpha1, beta1, gamma1, alpha2, beta2 and gamma2 with and without superimposition. The moment in time of the upper reversal point between the end of the back swing and the beginning of the forward swing is to be recognised as a vertical.

Figure 5 shows a typical measurement value curve of an experimentee at alpha1, beta1 and gamma1. In this case the alpha curve shows rotation, the beta curve shows sagittal flexion and the gamma curve shows lateral flexion, in this case the measurement point A_1Max shows the moment in time of the maximum rotation towards the left, the measurement time A_1Min shows the point of maximum

rotation towards the right, and so forth. It is particularly advantageous if that measurement curve of an experimentee is displayed on a display unit. The operator can immediately recognise therefrom the body behaviour of the experimentee in performing the golf swing and can draw his attention to any errors (see in that respect also claim 9). It will be appreciated that it is also possible for the measurement value curves of an experimentee at alpha2, alpha3, beta2, beta3, gamma2 and gamma3 to be represented on the display device.

Properties of the alpha1 curves:

The $\alpha 1$ curve detects the rotation of the spinal column at the location of the lower sensor. With the back swing movement the curve firstly goes into the negative region, to the maximum which we can view as an indicator for the beginning of the actual strike. With the swing, the curve goes from the negative region into the positive region, reaches a maximum and thereafter falls away again. The properties described hereinafter can now be automatically extracted from that curve. In regard to naming the individual properties of the curve, the Greek letters α, β and γ have been replaced by A, B and G in order to avoid font problems with the software used. All notations in regard to the moment in time relate to the beginning of the strike which is assumed to be at the minimum of the $\alpha 2$ curve (Figure 5).

A1-Pos0:	Zero position (starting position).
A1-Min:	Value of the minimum (angle at the beginning of the swing).
A1-Max:	Value of the maximum (angle at the end of the swing, see 'A1-SwTi').
A1-SwAngl:	Difference between A1-Max and A1-Min (total angle).
A1-SwTi:	Time between minimum and end of the swing. Here the moment in time of the maximum negative acceleration is viewed as the end of the swing (see below: 'A1-AccNegMaxTi'). In most alpha curves it appears appropriate to view the moment in time of the A1-maximum as the end of the swing, but unfortunately not every swing curve has a maximum which can be interpreted as a unique end of a swing. Therefore, instead, the value of 'A1-AccNegMaxTi' is used, which is more reliable in terms of detection.
A1-SwSpAv:	Average speed of rotation between the moment in time of the A1-minimum and the moment in time of the maximum negative acceleration.
A1-SwSpMax:	Maximum speed of rotation.
A1-SwSpMaxTi:	Moment in time of the maximum speed of rotation
A1-AccPosMax:	Maximum acceleration.
A1-AccPosMaxTi:	Moment in time of the maximum acceleration.
A1-AccNegMax:	Maximum negative acceleration (deceleration).
A1-AccNegMaxTi:	Moment in time of the maximum negative acceleration.

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Properties of the beta1 curves

The β1 curve involves the sagittal flexion of the spinal column at the lower sensor. Striking points are a maximum and a local minimum before the maximum and one thereafter. The following properties are extracted from the β1 curves:

B1-Pos0:	Zero position (starting position).
B1-Max:	Maximum.
B1-MaxTi:	Moment in time of the maximum.
B1-Min1:	First minimum (before the maximum).
B1-Min1Ti:	Moment in time of the first minimum.
B1-Min2:	Second minimum (after the maximum).
B1-Min2Ti:	Moment in time of the second minimum.
B1-SwAngl1:	Difference between maximum and minimum-1.
B1-SwAngl2:	Difference between maximum and minimum-2.
B1-Dmin1Min2:	Difference between minimum-1 and minimum-2.
B1-Tmin1Min2:	Time between minimum-1 and minimum-2.
B1-SwSpAv1:	Average speed between minimum-1 and maximum.
B1-SwSpAv2:	Average speed between maximum and minimum-2.
B1-SwSpMax1:	Maximum speed between minimum-1 and maximum.
B1-SwSpMax1Ti:	Moment in time of the maximum speed between minimum-1 and maximum
B1-SwSpMax2:	Maximum speed between maximum and minimum-2.
B1-SwSpMax2Ti:	Moment in time of the maximum speed between maximum and minimum-2.
B1-AccPosMax1:	Maximum acceleration between minimum-1 and maximum.
B1-AccPosMax1Ti:	Moment in time of the maximum acceleration between minimum-1 and maximum.
B1-AccNegMax1:	Maximum negative acceleration between minimum-1 and maximum.
B1-AccNegMax1Ti:	Moment in time of the maximum negative acceleration between minimum-1 and maximum.
B1-AccPosMax2:	Maximum acceleration between maximum and minimum-2.
B1-AccPosMax2Ti:	Moment in time of the maximum acceleration between maximum and minimum-2.
B1-AccNegMax2:	Maximum negative acceleration between maximum and minimum-2.
B1-AccNegMax2Ti:	Moment in time of the maximum negative acceleration between maximum and minimum-2.

The typical pronounced second minimum is not present in all β1 curves. In the cases in which the curve configuration is atypical, there is naturally also no usable value for the moment in time of the second minimum and the other

calculated properties which depend on that value. The properties extracted in that respect are then only limitedly comparable to those from curves with an 'typical' configuration.

Properties of the gamma1 curves

The $\gamma 1$ curve involves the lateral flexion of the spinal column at the lower sensor. Striking points are a minimum and a local maximum before that minimum and one thereafter. The following properties are extracted from the $\gamma 1$ curves:

G1-Pos0:	Zero position (starting position).
G1-Min:	Minimum.
G1-MinTi:	Moment in time of the minimum.
G1-Max1:	Maximum-1.
G1-Max1Ti:	Moment in time of the first maximum.
G1-Max2:	Maximum-2.
G1-Max2Ti:	Moment in time of the second maximum.
G1-SwAngl1:	Difference between maximum-1 and minimum.
G1-SwAngl2:	Difference between maximum-2 and minimum.
G1-Dmax1Max2:	Difference between maximum-1 and maximum-2.
G1-Tmax1Max2:	Time between maximum-1 and maximum-2.
G1-SwSpAv1:	Average speed between maximum-1 and minimum.
G1-SwSpAv2:	Average speed between minimum and maximum-2.
G1-SwSpMax1:	Maximum speed between maximum-1 and minimum.
G1-SwSpMax1Ti:	Moment in time of the maximum speed between maximum-1 and minimum.
G1-SwSpMax2:	Maximum speed between minimum and maximum-2.
G1-SwSpMax2Ti:	Moment in time of the maximum speed between minimum and maximum-2.
G1-AccPosMax1:	Maximum acceleration between maximum-1 and minimum.
G1-AccPosMax1Ti:	Moment in time of the maximum acceleration between maximum-1 and minimum.
G1-AccNegMax1:	Maximum negative acceleration between maximum-1 and minimum.
G1-AccNegMax1Ti:	Moment in time of the maximum negative acceleration between maximum-1 and minimum.
G1-AccPosMax2:	Maximum acceleration between minimum and maximum-2.
G1-AccPosMax2Ti:	Moment in time of the maximum acceleration between minimum and maximum-2.
G1-AccNegMax2:	Maximum negative acceleration between minimum and maximum-2.
G1-AccNegMax2Ti:	Moment in time of the maximum negative acceleration between minimum and maximum-2.

Here extraction of the second local maximum in part gives rise to problems. In the case of many players (or swings) it is severely pronounced, whereas in many cases there is not a pronounced minimum in the area in question of 140 measurement values. The curve shown in Figure 1 also does not involve a 'typical' local maximum: the curve rises to the end of the region being considered of 140 values.

Properties of the curves relating to alpha2, beta2, gamma2.

The similarity between the structures of the two alpha curves ($\alpha 1$ and $\alpha 2$) is so great that the same properties can be extracted for both curves. The same applies for the two beta curves and the two gamma curves. Overall therefore for each swing 124 properties of the three curves are extracted: 12 each for the alpha curves and 25 each for the beta and gamma curves. In the designations of the curve properties, A stands for α, B for β and G for γ. All moment in time notations in the α, β and γ curves relate to the beginning of the strike which is assumed to be at the minimum of the $\alpha 2$ curve.

Figures 6a through h show in 124 different views the card recording of all parameters.

Figure 7 also shows card recording in 20 views, in regard to which other parameters not involving the golf swing are taken into account. Such parameters are for example the age of the experimentee, his height, his weight, the time he has been playing golf, his handicap and so forth.

Figure 8 shows the measurement arrangement for an experimentee, which is provided with three ultrasonic pick-ups whose recorded values are received by a data processing apparatus coupled thereto.